Mass Spectrometry: Principles and Applications

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Mass Spectrometry: Principles and Application by E. De Hoffmann, J. Charette, and V. Stroobant presents a comprehensive overview of mass spectrometry, its principles, instrumental methods, and applications. The book is written at a moderately basic level and could be envisioned as an introductory textbook for a mass spectrometry course or as a basic reference book for those wishing to familiarize themselves with mass spectrometry. The book is filled with numerous figures and tables that greatly assist in the presentation of instrumentation, mass spectral examples, and fragmentation pathways. The text is concise and organized in such a way that one can skip to different sections and fully comprehend the material without extensive background. In addition, numerous references are scattered throughout the text, thus guiding readers to more detailed articles and supplementary material.

The book is divided into eight chapters, the last one of which is a series of exercises with solutions. The first four chapters are devoted to descriptions of instrumentation aspects of mass spectrometry: Chapter 1 covers ionization techniques, Chapter 2 describes mass analyzers, Chapter 3 discusses the combination of chromatography with mass spectrometry, and Chapter 4 covers tandem mass spectrometry. Chapter 5 is entitled "Analytical Information," and it focuses on such topics as isotopic abundances and quantitative methods. Chapter 6 describes fragmentation processes and spectral interpretation, and Chapter 7 covers the analysis of biomolecules. The individual chapters are generally well written and nicely organized, and the extensive use of graphics interspersed with short paragraphs makes the book delightful to read. However, the occurrence of misleading or incorrect statements, on average four to six per chapter, is rather unsettling. An expert in the area of mass spectrometry will find these errors to be annoying, whereas a novice will mistakenly accept them as correct information. For example, in the Introduction, the authors state that "the maximum pressure in a mass spectrometer should be 66 nbar" (~0.05 mtorr). The quadrupole ion trap operates at 1 mtorr routinely; thus, the statement is an oversimplification. Chapter 1 presents a good overview of ionization methods with numerous outstanding figures. However, a rather unusual explanation for the mechanism of electron ionization is given, which describes the wavelengths of electrons and how they perturb transitions of molecules if the wavelengths are close to bond lengths of molecules. This explanation is a little confusing because atomic species don't have any "bond lengths" and yet they are efficiently ionized by electrons. In the section on laser desorption, one of the stated advantages of matrix-assisted laser desorption ionization is "It is no longer necessary to adjust the wavelength to match the absorption frequency of each analyte." However, in most conventional infrared laser desorption modes, the laser creates a thermal spike, and thus, it is not necessary to match the laser wavelength with the sample.

Chapter 2 is a fine description of mass analyzers, including hybrid instruments and a nice concise section on detectors. However, in the section entitled "Spectrometers with Several Quadrupoles," there is a notable error in the sentence ". . . kinetic energy is transferred to the ion by converting a fraction of the collision energy into internal energy." The correct statement should read ". . . internal energy transferred to the ion by conversion of a fraction of the kinetic energy into internal energy." This type of error provides a confusing depiction of collisional activation to the readers. In the section on time-of-flight analyzers, it is stated that "pulsed laser desorption requires a time-of-flight analyzer." This statement is untrue because of the successful combinations of Fourier transform ion cyclotron resonance (FTICR) or ion trap mass spectrometers with laser desorption methods. Chapter 3, entitled "Mass Spectrometry–Chromatography Coupling," clearly presents the numerous chromatographic interfaces. Unfortunately, the figure in the liquid chromatography–mass spectrometry (LC-MS) section that illustrates the compatibility of various ionization methods for various compound types is an excellent visual aid, but again the terms used in the figure are misguided. The authors try to convey the range of samples from nonpolar to polar to ionic, but they mistakenly use the terms "neutral," "polar," and "ionic." The term "neutral" encompasses both polar and nonpolar compounds and could be very confusing to a novice.

Chapter 4 is a short but adequate description of tandem mass spectrometry. Unfortunately, the definition of tandem mass spectrometry given at the beginning of the chapter is incorrect. The authors state that it is "a method in which a first analyzer isolates a precursor ion, which then undergoes a fragmentation yielding product ions and neutral fragments." Thus, the authors have implied that tandem mass spectrometry is a method for examining fragmentation of ions. However,

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tandem mass spectrometry is any general method involving at least two stages of mass analysis, either in conjunction with a chemical reaction or a dissociation process that causes a change in the mass or charge of an ion. Chapter 5 touches on a variety of important concepts in analytical mass spectrometry, such as detection limits, resolution, and sensitivity, and offers a lot of useful information about quantitative analysis. Chapter 6 focuses on fragmentation pathways and even nicely discusses the dissociation of even electron ions, a topic that is often skipped despite the fact that all protonated molecules formed by fast-atom bombardment (FAB), electrospray ionization (ESI), and matrix-assisted laser desorption ionization (MALDI) are even electron ions. Chapter 7 is one of the best chapters because it presents the many applications of biological mass spectrometry at a basic but still highly informative level. Table 7.2, which presents a summary of the applicability of various ionization methods, is incomplete because it fails to note that FAB, ESI, and MALDI can be used with both FTICR and quadrupole ion trap instruments, and thus the table might be misleading to readers searching for a quick overview of the applicability of various ionization methods for peptide/protein analysis.

The final chapter is a short collection of exercises; some of the spectral interpretations are probably too challenging for a novice and are inadequately explained in the solution section. Eleven appendices are also included, ranging from nomenclature and abbreviations to tables of gas-phase acidities and basicities to tables of isotope information. Most of the appendices are quite handy, even for mass spectrometry specialists, but the tables containing thermochemical values are inadequately referenced and only marginally explained for the novice.

In summary, the book is easy to read and the general content is quite satisfactory—in fact, an incredible amount of material is covered very concisely. Because of the fair number of misleading statements throughout the book, the details of the material presented should be viewed somewhat cautiously, and readers should confirm specific details by checking other references. If this book were used in a course on mass spectrometry, the instructor could probably fill in the gaps and correct the problems in the text. The book would benefit greatly by careful revision, and the next edition has the potential for being an outstanding basic textbook or handbook for those interested in mass spectrometry.